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Multi-variate Empirical Mode Decomposition (MEMD) for ambient modal identification of RC road bridge

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Abstract. In this paper, an adaptive MEMD based modal identification technique for linear time-invariant systems is proposed employing multiple vibration measurements. Traditional empirical mode decomposition (EMD) suffers from mode-mixing during sifting operations to identify intrinsic mode functions (IMF). MEMD performs better in this context as it considers multi-channel data and projects them into a $n-$dimensional hypercube to evaluate the IMFs. Using this technique, modal parameters of the structural system are identified. It is observed that MEMD has superior performance compared to its traditional counterpart. However, it still suffers from mild mode-mixing in higher modes where the energy contents are low. To avoid this problem, an adaptive filtering scheme is proposed to decompose the interfering modes. The Proposed modified scheme is then applied to vibrations of a reinforced concrete road bridge. Results presented in this study show that the proposed MEMD based approach coupled with the filtering technique can effectively identify the parameters of the dominant modes present in the structural response with a significant level of accuracy.

Keywords: hilbert transform; Multi-variate Empirical Mode Decomposition; intrinsic mode function; operational modal analysis; modal parameters of bridge

1. Introduction

The output-only vibrations based modal identification techniques have shown excellent capabilities in the health monitoring of civil infrastructure. Researchers use different time, frequency, and time-frequency domain algorithms, and many literature can be found on this topic (Maria and Silva 2001, Zhao *et al.* 2018, Li *et al.* 2014, Mahato and Chakraborty 2016, Mahato *et al.* 2020). Recently, robust signal processing methods including blind source separation (BSS) principles (Antoni *et al.* 2004, Hazra *et al.* 2010, Huang and Nagarajaiah 2014, Yang *et al.* 2020), wavelet transformation (Staszewski and Robertson 2007, Mahato and Chakraborty 2019), and Hilbert-Huang transform (Huang *et al.* 1998, Yang *et al.* 2003, 2004, Chen *et al.* 2017, Mahato *et al.* 2017) have been investigated in numerous structural health monitoring applications. Unlike any other time-frequency decomposition tools, EMD can deal with the nonlinear and non-stationary

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